



ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Pliers and Wrenches

Harry W. Edwards*, Michael F. Kostrzewa*,
and Gwen P. Looby**

Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. In an effort to assist these manufacturers, Waste Minimization Assessment Centers (WMACs) were established at selected universities and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at Colorado State University performed an assessment at a plant that manufactures pliers and wrenches. The products are manufactured from metal blanks that have been forged in another plant. In the case of the pliers, the blanks are machined, etched, primed, and assembled. The handles are then plastic coated and the finished pliers are inspected, packaged, and shipped. For wrench manufacture, the metal blanks are nickel- and chromium-plated, inspected, and packaged. The team's report, detailing findings and recommendations, indicated that the greatest quantity of waste in this plant came from the machining and plating operations. The greatest cost-saving opportunity recommended to the plant involved the replacement of 1,1,1-trichloroethane vapor degreasing with nonhazardous aqueous cleaning.

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from University City Science Center, Philadelphia, PA.

* Colorado State University, Department of Mechanical Engineering, Fort Collins, CO

** University City Science Center, Philadelphia, PA

Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste generation is to reduce or eliminate the waste at its source.

University City Science Center has begun a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the in-house expertise to do so. Under agreement with EPA's Risk Reduction Engineering Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at Colorado State University's (Fort Collins) WMAC. The assessment teams have considerable direct experience with process operations in manufacturing plants and also have the knowledge and skills needed to minimize waste generation.

The waste minimization assessments are done for small and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding \$75 million, employ no more than 500 persons, and lack in-house expertise in waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers and reduction of waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program and a cleaner environment without more regulations and higher costs for manufacturers.

Methodology of Assessments

The waste minimization assessments require several site visits to each client served. In general, the WMACs follow the procedures outlined in the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC staff locate the sources of waste in the plant and identify the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report that details the WMAC's findings and recommendations (including cost savings, implementation costs, and payback times) is prepared for each client.

Plant Background

The plant manufactures pliers (adjustable and needle-nose) and wrenches that are distributed nationally. It operates 7,200 hr/yr to produce almost ten million pieces annually.

Manufacturing Process

The principal raw materials used by this plant are metal blanks that have been forged in another plant.

Plier Manufacture

In the production of adjustable pliers, the metal blanks are trimmed and coined to dimension and straightened. Then, one or two holes are pierced in each blank for the joint connection. Next, arcs are cut into the blanks using broaches that also cut teeth into the blanks. The plier handles are then ground using vertical broaches. Heat treating, sandblasting, and polishing of the blanks follow.

Brand names are etched on the single-hole blanks using acid. Then, those blanks are dipped in clear-coat primer that acts as a sealant and provides corrosion protection. Primer is also applied to double-hole blanks, but in this case, spray application is used.

The finished halves are assembled using nuts, bolts, and washers. Plier handles are then dipped in molten plastic for coating. The finished pliers are allowed to cool, inspected, packaged, and shipped.

The processes used in needle-nose plier manufacture are similar to those used in producing adjustable pliers. In this case, however, the pliers are etched using a laser instead of acid. In addition, vapor degreasing is required before plastic coating.

An abbreviated process flow diagram for plier manufacture is shown in Figure 1.

Wrench Manufacture

In the manufacture of wrenches, polished metal blanks are loaded into racks for processing. The racks are sent through an automated plating machine for electroless nickel-plating and electrolytic trivalent-chromium-plating. The plated wrenches are then unloaded, inspected, and packaged.

An abbreviated process flow diagram for wrench manufacturer is shown in Figure 2.

Existing Waste Management Practices

This plant already has implemented the following techniques to manage and minimize its wastes:

- Many of the machining operations require no cutting fluid and therefore generate no waste cutting fluid.
- A cutting fluid reuse program has been developed and implemented successfully.
- Waste oil is separated from waste cutting fluid and rebled off-site for use as industrial boiler fuel.
- 1,1,1-trichloroethane has replaced perchloroethylene as the degreasing agent, thereby reducing slightly the toxicity of the solvent used for cleaning the pliers.
- The plant plans to replace the spray priming system with a dip priming system that will generate less waste.
- An acid purification unit (APU) has been installed in conjunction with the nitric acid rack stripper in the plating area. The APU removes dissolved nickel from the acid so that the bath can be regenerated without being dumped.
- Nickel plating solution is filtered and reused. Drag-out tanks are used in the plating line to reduce nickel drag-out into the rinse streams.
- Liquid nitrogen instead of solvent is used to remove plastic coating from rejected pliers.
- Whenever possible, waste plastic coating, instead of being disposed of, is returned to the manufacturer. Cross-contamination of coatings is minimized.
- Flow reducers have been installed on the rinses in the plating line.

Waste Minimization Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of the waste, and the annual waste management costs are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team recommended for the plant. The minimization opportunity, the type of waste, the possible waste reduction and associated savings, and the implementation cost along with the payback time are given in the table. The quantities of waste currently generated by the plant and possible waste reduction depend on the production level of the plant. All values should be considered in that context.

It should be noted that the financial savings of the minimization opportunities result from the need for less raw material and from reduced present and future costs associated with waste management. Other savings not quantifiable by this study include a wide variety of possible future costs related to changing emissions standards, liability, and employee health. It also should be noted that the savings given for each opportunity reflect the savings achievable when implementing each waste minimization opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package.

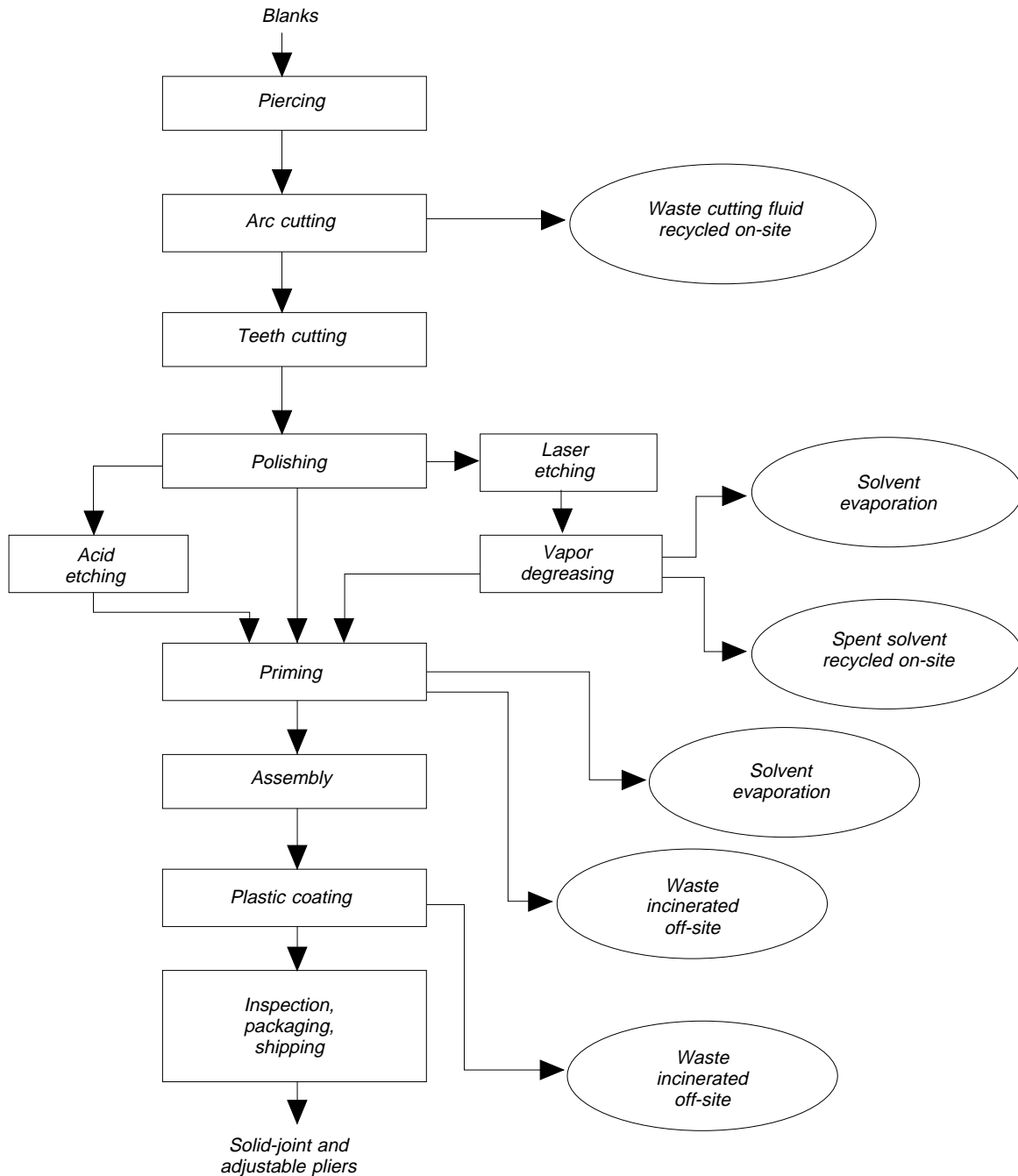


Figure 1. Abbreviated process flow diagram for plier manufacture.

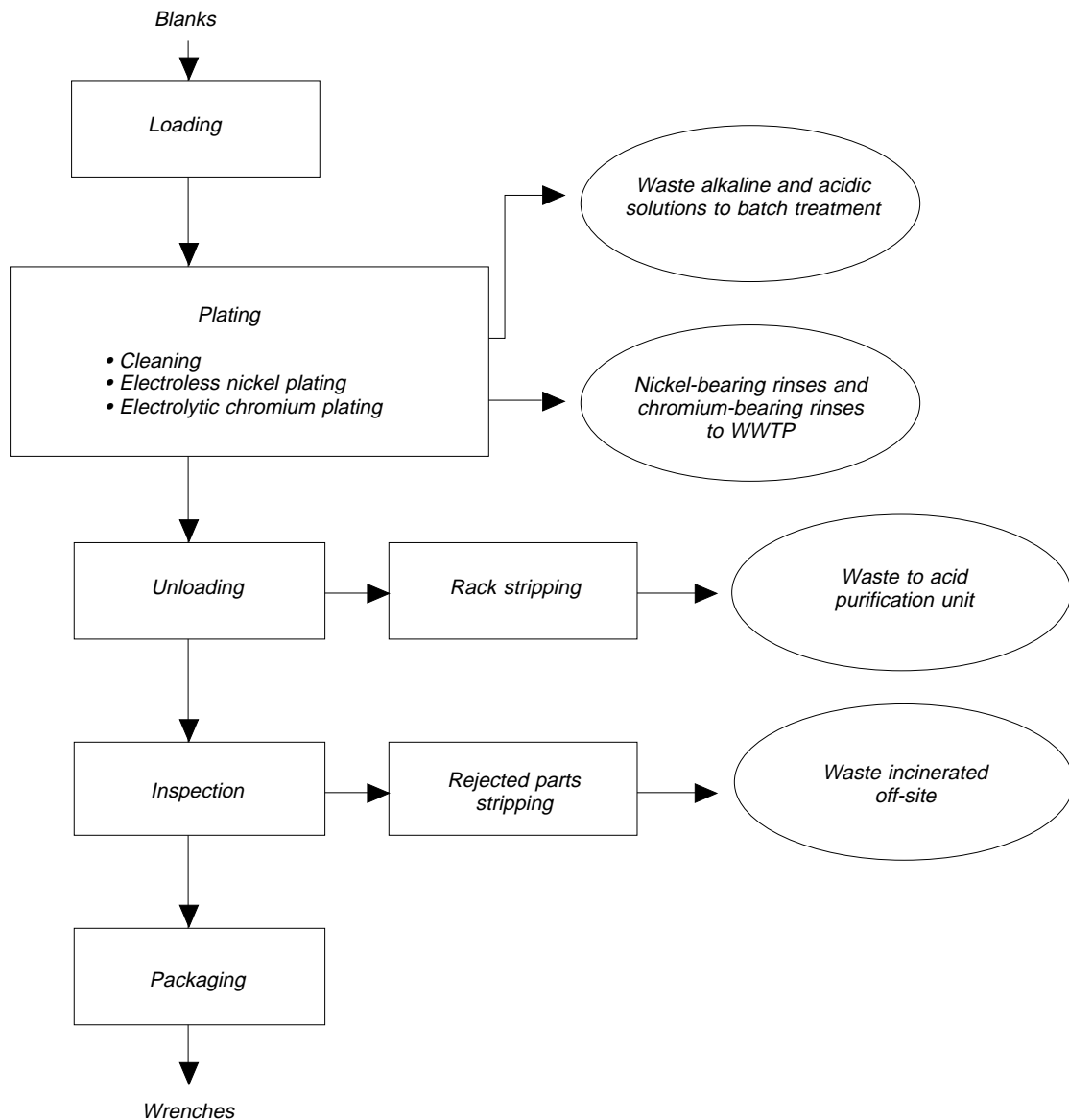


Figure 2. Abbreviated process flow diagram for wrench manufacture.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, two additional measures were considered. These measures were not completely analyzed because of insufficient data, minimal savings, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to waste reduction may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Remove chromium and nickel from rejected parts using an electro-soap cleaner instead of the currently used stripper.

- Electrowin nickel from the effluent of the acid purification unit to reduce the amount of nickel discharged to the on-site waste water treatment system that eventually ends up as metal hydroxide sludge.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-814903 by the University City Science Center under the sponsorship of the U.S. Environmental Protection Agency. The EPA Project Officer was **Emma Lou George**.

Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb)	Annual Waste Management Cost*
Spent cutting fluid	Machining (cutting fluid that can no longer be reused)	Shipped off-site to be reblended into fuel	1,053,410	\$88,540
Waste oil	Machining (removed from cutting fluid during on-site recycling)	Shipped off-site to be reblended into fuel	103,970	5,630
Reusable cutting fluid	Machining (cutting fluid that can be reused)	Reused in process	2,041,690	2,100
Spent 1,1,1-trichloroethane	Vapor degreasing	Shipped off-site for incineration	520	900
Still bottoms	On-site recycling unit for 1,1,1-trichloroethane	Shipped off-site for incineration	520	900
Evaporated 1,1,1-trichloroethane	Vapor degreasing	Evaporates to plant air	44,360	21,370
Spent perchloroethylene (no longer in use)	Vapor degreasing	Shipped off-site for incineration	13,000	3,440
Waste methyl ethyl ketone	Dip priming	Shipped off-site for incineration	3,730	6,460
Evaporated methyl ethyl ketone	Dip priming	Evaporates to plant air	700	450
Evaporated xylene	Spray priming	Evaporates to plant air	10,080	2,600
Waste primer	Priming	Shipped off-site for incineration	4,100	9,250
Paint filters and rags	Spray priming	Shipped off-site for incineration	59,480	60,170
Waste plastic coating	Plastic coating	Shipped off-site for incineration	7,500	14,700
Spent plastic stripper	Removal of plastic coating	Shipped off-site for incineration	420	260
Spent rinse water	Plating line	Treated on-site; sewer	22,178,950	54,280
Metal hydroxide sludge	Water treatment	Shipped to disposal facility	164,330	32,450
Waste metal stripper	Removal of plating from rejected parts	pH adjusted; shipped off-site for incineration	75,230	31,540
Waste solvent	Plating line	Shipped off-site for incineration	2,250	3,830
Waste buffing compound	Machining	Shipped off-site for incorporation into cement	3,330	1,530
Miscellaneous waste	Various processes	Shipped off-site for incineration	5,550	3,280

* Includes waste treatment, disposal, handling costs, and applicable raw material costs.

Table 2. Summary of Recommended Waste Minimization Opportunities

Minimization Opportunity	Waste Stream Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yr)
		Quantity (lb)	Per cent			
Replace 1,1,1-trichloroethane vapor degreasing with an aqueous cleaning system. Nonhazardous liquid waste will be generated during periodic replacement of the cleaner and associated rinses if this opportunity is implemented. ¹	Spent 1,1,1-trichloroethane	520	100	\$21,280	\$60,490	2.8
	Still bottoms	520	100			
	Evaporated 1,1,1-trichloroethane	44,360	100			
Replace the cutting fluid currently used in the broaches with a vegetable-oil based spray coolant system. When used properly, the proposed oil is consumed completely during cutting.	Spent cutting fluid	227,000	22	5,680	11,000	1.9
	Reusable cutting fluid	40,000	22			

¹ It was estimated that a total of 77,000 lb/yr of waste nonhazardous cleaning solution and rinse water will be generated if this opportunity is implemented.

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use
\$300

EPA/600/S-94/004

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35